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PESTICIDE RESEARCH PROJECTS

Funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee

1984 – 1985

Ontario

The Ontario Pesticides Advisory Committee

Hon. Jim Bradley
Minister
Rod McLeod,Q.C.
Deputy Minister

ISSN 0830 - 0267

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FUNDED BY

THE MINISTRY OF THE ENVIRONMENT

THROUGH

THE ONTARIO PESTICIDES ADVISORY COMMITTEE

1984 - 1985

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PESTICIDE RESEARCH PROJECTS FUNDED BY THE MINISTRY OF THE ENVIRONMENT THROUGH THE ONTARIO PESTICIDES ADVISORY COMMITTEE, 1984-85

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EXECUTIVE SUMMARY

1. In 1984-85, the Ontario Pesticides Advisory Committee continued a program, begun in 1973, of funding research on pesticides. The objectives of the program are:

   (a) To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.

   (b) To determine potential environmental hazards with pesticides currently in use.

   (c) To reduce pesticide input into the environment.

2. The research budget was $300,000.

3. Forty-six research proposals totalling $557,828 were received.

4. Thirty proposals were funded with a total value of $296,080. Awards averaged $9,869, and ranged from $3,800 to $15,500.

5. Five grants totalling $36,200 were awarded for studies on development of alternative pesticides.

6. Seven grants totalling $79,950 were allocated to studies on the behaviour and fate of pesticides in the environment and on potential environmental hazards to non-target organisms.

7. Eighteen grants totalling $179,930 were allocated for studies aimed at reducing pesticide input into the environment, while still achieving effective pest control.

8. The Pesticides Advisory Committee is very satisfied with the research progress in 1984-85. It recognizes that, with the limited funds available, the program can be expected to act only as a catalyst in stimulating support by other interested agencies for urgently required research in the broad areas indicated in the Committee's guidelines.

9. **The Pesticides Advisory Committee recommends that:**

   i) The Ministry of the Environment continue to support research programs directed toward development of pest control programs which will not pose any serious environmental hazard.

   ii) The Pesticides Advisory Committee continue to supervise the program following guidelines which have been developed.

I. OBJECTIVES

The Ministry of the Environment first allocated funds to the Ontario Pesticides Advisory Committee (OPAC) to sponsor pesticide-related research in 1973. Terms of Reference developed by OPAC to govern the awarding of research grants are based on three general objectives:

1) To find alternative pesticides for those deemed environmentally hazardous and thus restricted for use.

2) To determine potential environmental hazards with pesticides currently in use.

3) To reduce pesticide input into the environment.

An "Application for Research Support", which invites research proposals in several specific areas relating to the program objectives is reviewed and revised annually by OPAC in consultation with the Ministry of the Environment Research Advisory Committee. In 1984-85, research proposals were invited in six specific areas relating to the three research objectives (Appendix I).

II. SELECTION PROCEDURE

Notices inviting applications for research support were widely distributed in January, 1984 to researchers and administrators in Ontario universities, industry, government, and other organizations, with the deadline for receipt of applications being February 29, 1984. In March, applications were considered by the OPAC Research Subcommittee comprising eight members (P.D. Foley, R. Frank, J.C. Ingratta, B.H. McGauley, J.J. Onderdonk, K.R. Solomon, G.R. Stephenson, and C.R. Harris (Chairman)), all of whom had a broad knowledge of pesticides and problems of pest control. Criteria used in judging applications included: 1) applicability to research objectives; 2) scientific quality of research proposal; and 3) ability of applicant(s) to carry out research as proposed. Recommendations prepared by the Research Subcommittee were reviewed by the entire Pesticides Advisory Committee. OPAC recommendations were then forwarded to the MOE Research Advisory Committee for confirmation and funding. Funds were made available to grant recipients by June, 1984.

III. PROJECTS SUPPORTED

The OPAC research budget in 1984-85 was $300,000.

Forty-six research proposals totalling $557,828 were received. Most (38) were from universities/colleges (Brock, Guelph, McMaster, Queen's, Sault College of Applied Arts and Technology, Toronto, Trent, and Western). The remaining applications were submitted by industry or other organizations. Thirty proposals (Appendix II), primarily from researchers affiliated with universities were accepted. Awards averaged $9,868 (range $3,800 to $15,500). Disbursement of research funds by organization is summarized below:

Organization	Number of Research Grants Awarded	$ Total Research Funds
University of Guelph	13	129,050
University of Western Ont.	6	80,830
University of Toronto	1	7,000
Sault College of Applied Technology	2	8,200
Other	8	71,000
TOTAL	30	296,080

Results obtained in the various studies are summarized in Appendix III. Five grants (Abstract #1, 12, 17, 22, 23) totalling $36,200 were awarded for studies on development of alternative pesticides for those deemed environmentally hazardous and thus restricted in use. Seven grants (2, 5, 10, 21, 24, 25, 26) totalling $79,950 were allocated for studies to determine potential environmental hazards with pesticides presently in use. Eighteen grants (3, 4, 6, 7, 8, 9, 11, 13, 14, 15, 16, 18, 19, 20, 27, 28, 29, 30) totalling $179,930 were allocated for studies aimed at reducing pesticide input into the environment, while still achieving effective pest control.

IV. ACCOUNTABILITY

Direction and progress of the research were monitored by OPAC in several ways. Initially, some applicants were asked to modify their proposals to better meet the research guidelines. In several instances, OPAC members met with applicants to discuss their research proposals and to suggest modifications where necessary. In June, 1984, as a part of the Annual OPAC

field trip, visits to researchers receiving financial support were included on the agenda, thus giving OPAC members an opportunity to become acquainted with cooperating scientists and research in progress. In September, several OPAC members attended a research conference organized by recipients of one research grant. Informal contacts between OPAC members and grant recipients were established and maintained throughout the year. In January, 1985, OPAC sponsored a two-day meeting at which grant recipients presented their research results. This meeting was attended by OPAC members and more than 80 guests interested in pesticide-related research. In addition, grant recipients were required to provide OPAC with a summary of results (Appendix III) and, where necessary, a comprehensive project report.

Research reports, manuals, theses, etc., published in 1984-85 relating to OPAC sponsored research are listed in Appendix IV. In addition, 1984-85 research data are expected to serve as the basis for at least three Factsheets and one slide presentation for public education and for four official OPAC reports.

V. RECOMMENDATIONS

The Pesticides Advisory Committee is pleased with research progress made in 1984-85. The Committee recognizes that with the limited funds available, the program can be expected to act only as a catalyst in stimulating support by other interested agencies for urgently required research in the broad areas indicated in the Committee's guidelines. The Committee recommends that:

(1) The Ministry of the Environment continue to support this very productive research program directed toward development of pest control programs which will not pose any serious environmental hazard.

(2) The Ontario Pesticides Advisory Committee continue to supervise this program following the guidelines which have been developed. With its broad expertise, strong scientific background and close liaison with the scientific community, OPAC is in the unique position of being able to define research priorities and to ensure that excellent value is received for money spent.

APPENDIX I: FORMAT OF ADVERTISEMENT INVITING APPLICATIONS FOR RESEARCH SUPPORT FROM THE ONTARIO PESTICIDES ADVISORY COMMITTEE

January, 1984

APPLICATION FOR RESEARCH SUPPORT

The Ontario Ministry of the Environment has a limited amount of funds available for 1984 to sponsor research aimed at: (1) developing alternative pesticides for those deemed environmentally hazardous and thus restricted in use; (2) determining potential environmental hazards associated with pesticides currently in use; and (3) developing alternative approaches to pest control in order to reduce total pesticide input into the environment. Preference will be given to proposals yielding results in a relatively short time, with funds being committed on a yearly basis. Research should be in the context of normal use patterns.

The Ministry invites research proposals in the following areas:

1. Economics of pest[1] control including development of crop loss estimates and determination of economic thresholds of damage.

2. Studies leading to development of environmentally acceptable pesticides[2], especially for use on horticultural crops.

3. Reduction of pesticide use through development of pest monitoring techniques; improved application procedures; or integrated or non-chemical methods of pest control.

4. Development of efficient techniques of pesticide application.

5. Development of information on time which should elapse between dates of treatment and re-entry into treated areas including buildings, and on exposure of agricultural workers, licensed exterminators, and the public to pesticides.

6. Studies on the persistence, degradation, mobility, and biological significance of pesticide residues in the environment.

APPLICATION PROCEDURES

Research proposals should be submitted to:

The Chairman
Pesticides Advisory Committee
Ministry of the Environment
Suite 100, 135 St. Clair Avenue West
Toronto, Ontario M4V 1P5

Applications should be received by February 29, 1984, and should include the following:

1. Title of project.
2. Name, address and affiliation of applicant(s).
3. Discussion of problem.
4. Clear statement of objective(s).
5. Plan for program.
6. Facilities available.
7. Budget - categorize costs as: Personnel - full/time and part/time, Equipment, Supplies, Overhead Costs, Other.
8. Listing of current projects and other sources of funding.
9. Curriculum vitae on principal investigator(s) (if not already on file with the Pesticides Advisory Committee).

Successful applicants must submit an abstract by year's end and present a progress report at the Committee's annual research seminar held each January. A financial report may be required at the discretion of the Ministry of the Environment.

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[1] "Pest" means any injurious, noxious or troublesome plant or animal life other than man or plant or animal life on or in man and includes any injurious, noxious or troublesome organic function of a plant or animal (Pesticides Act, Chapter 376, S.1 (s).)

[2] "Pesticide" means any organism, substance or thing that is manufactured, represented, sold or used as a means of directly or indirectly controlling, preventing, destroying, mitigating, attracting or repelling any pest or of altering the growth, development or characteristics of any plant life that is not a pest and includes any organism, substance or thing registered under the Pest Control Products Act (Canada); (Pesticides Act, Chapter 376, S.1. (t).)

APPENDIX II: RESEARCH PROJECTS SUPPORTED BY THE ONTARIO PESTICIDES ADVISORY COMMITTEE, 1984-85

No.	APPLICANT(S)	LOCATION	PROJECT TITLE	$ AMOUNT GRANTED
1.	Blaine, W.D.	Chemical Research Int.	A study of the biology and control of the carpenter ant through the use of insecticidal baits.	4,500
2.	Bond, E.J.	University of Western Ontario	Residues of methyl bromide in fumigated commodities and relationship of the treatments to safety of the working environment.	14,800
3.	Burpee, L.L.	University of Guelph	Integrated management of turfgrass diseases in Ontario.	8,500
4.	Cavers, P.B.	University of Western Ontario	Seed viability, dormancy and over-wintering in different populations of proso millet.	11,900
5.	Chapman, R.A. Harris, C.R.	University of Western Ontario	Persistence and degradation in soil of insecticides recommended in Ontario for corn rootworm control.	14, 900
6.	Edgington, L.V.	University of Guelph	Biological control of white rot of onion by Sporidesmium sclerotivorum in muck soil.	8,600
7.	Ellis, C.R.	University of Guelph	Development of suitable monitoring methods and economic thresholds for corn rootworms.	15,000
8.	Gillespie, T.J.	University of Guelph	A field guide on surface wetness duration sensors.	5,000

No.	APPLICANT(S)	LOCATION	PROJECT TITLE	$ AMOUNT GRANTED
9.	Hubbes, M.	University of Toronto	Feasibility of using the egg parasite, Trichogramma minutum, for biological control of the spruce budworm.	7,000
10.	Kaushik, N.K.	University of Guelph	Studies on the toxicity of fenvalerate to filter-feeding zooplankton in an aquatic system.	12,650
11.	Leili, H. Makey, S.	Ontario Vegetable Grower's Marketing Board	Weather-timed fungicide application on tomatoes for improved disease control and reduction of fungicide use.	8,000
12.	Machado, V.S.	University of Guelph	Efficacy of alternative herbicides to allidochlor in onions.	8,000
13.	Madder, D.J. Stemeroff, M.	Culice Co.	A study of the costs and benefits of the development, implementation and maintenance of integrated pest management programs in Ontario.	11,300
14.	Madder, D.J. Stemeroff, M.	Culice Co.	Feasibility and economics of the development, implementation, and maintenance of an integrated pest management program on potatoes in Ontario.	14,500
15.	McLeod, D.G.R. Tolman, J.H.	University of Western Ontario	Losses in production of processing tomatoes and cabbage attributable to insects, diseases and weeds.	12,500
16.	Northover, J. Biggs, A.R. Frank, R.	Tender Fruit Marketing Board	Application of epidemiology to reduce fungicide requirements for controlling brown rot of stone fruits.	7,200

No.	APPLICANT(S)	LOCATION	PROJECT TITLE	$ AMOUNT GRANTED
17.	Pree, D.J.	Ontario Apple Marketing Commission	Status of pesticide resistance in the spotted tentiform leafminer and European red mite in apple growing regions of Ontario.	8,500
18.	Sanders, C.J.	Sault College	Development of sex attractant traps for monitoring changes in low density spruce budworm populations as a means of implementing early intervention management strategies.	4,400
19.	Sanders, C.J.	Sault College	Development of sex attractant traps for monitoring Jack pine budworm population fluctuations.	3,800
20.	Sears, M.K.	University of Guelph	Crop loss associated with pests attacking canola in Ontario.	10,500
21.	Siddiqui, Z.	Chemical Research Int.	Environmental fate analysis of pesticides after application in buildings for structural pest control.	7,600
22.	Siddiqui, Z.	Chemical Research Int.	Meadow mouse control in apple orchards.	9,400
23.	Smith, D.W.	University of Guelph	Study of the herbicidal properties and environmental fate of triclopyr.	5,800
24.	Solomon, K.R. Stephenson, G.R.	University of Guelph	Determination of the persistence of 2,4-D in northern and southern Ontario aquatic environments.	15,500
25.	Stephenson, G.R. Sears, M.K.	University of Guelph	Dislodgeable pesticide residues in turfgrass in relation to safe entry.	9,300

No.	APPLICANT(S)	LOCATION	PROJECT TITLE	$ AMOUNT GRANTED
26.	Stephenson, G.R. Solomon, K.R.	University of Guelph	A review of literature on specific pesticides and related issues to determine future research directions of the Pesticides Advisory Committee.	5,200
27.	Surgeoner, G.A.	University of Guelph	Biological control of the house fly.	13,000
28.	Sutton, J.C.	University of Guelph	New approaches to managing botrytis grey mold in strawberries.	12,000
29.	Tolman, J.H. Tomlin, A.D.	University of Western Ontario	Integrated management of root maggots attacking vegetable crops.	14,880
30.	Tu, C.M. Harris, C.R.	University of Western Ontario	Feasibility of culture and use of Entomophthora muscae as an alternative to insecticides in insect control.	11,850
	TOTAL----------			$296,080

APPENDIX III: REPORTS (ABSTRACTS) OF PROJECTS FUNDED BY THE ONTARIO PESTICIDES ADVISORY COMMITTEE, 1984-85

1. BLAINE, W.D. - A study of the biology and control of the carpenter ant through the use of insecticidal baits.

A study was carried out to evaluate the use of insecticidal baits and attractants for control of the carpenter ant. The biology was studied to determine if this would provide information which might be useful in control.

The carpenter ants used were collected from wooded areas in southern Ontario.

Colonies were kept in the laboratory where they were supplied with honey and bran as a food source.

Earlier testing had shown that insecticidal baits were ineffective as a control measure against the carpenter ant. The ants would seem to be able to detect the insecticide in the bait. Ficam®, Baygon®, chlordecone, borax, and chlordane were tested as baits. Tests were also carried out on the attractiveness of baits. While ants will readily feed on sweet materials such as honey, corn syrup and molasses, these do not attract the ants over any distance. Fusel oil, an aromatic by-product in the distilling industry, was tested for attractiveness. While it was readily detected by the ants over a distance of three feet, it did not attract the ants to the bait.

When baits were made up using Ficam at 0.05% and fusel oil at 1% in bran and honey base, the ants would first feed on the bait, but after several days feeding would cease. This pattern is similar to that found when only Ficam, bran and honey, or bran and honey and one of the insecticides previously mentioned was used. A second insecticide, Amdro®, which is not detectable by insects, was also tested. Ants fed readily on this material throughout the test and colony destruction occurred. Colony destruction could also be attained using a water-sugar based bait.

Tests were carried out to determine whether foraging ants use pheromone trails to pinpoint food sources. If this is true, controlled release formulations containing both pheromone and pesticide might be used for control. Results show that the ants do use trail pheromones.

One of the problems of control using baits may be that the proportion of ants actively engaged in foraging is very low. Tests using a photo-electric sensor to determine foraging behaviour are commencing.

2. BOND, E.J. - Residues resulting from fumigation of food commodities with methyl bromide.

The purpose of this investigation was to determine quantities of methyl bromide residue retained in food commodities after treatments and then to determine the nature of the reaction products formed. The commodity chosen for the first part of the investigation was yellow dent corn and the fumigation procedure involved 5 consecutive weekly treatments over a period of 5 weeks.

This investigation was initiated in September 1983 to provide the much needed data on residues, particularly in treatments when high levels of residue might occur. As some commodities may be treated at several stages during storage and processing to eliminate insect infestation, the investigation was designed to give data on residues likely to occur after such repeated treatments.

In the first part of the project, methods for fumigating samples of commodities with ^{14}C methyl bromide were developed using yellow dent corn (maize) as the test material. Data on residue levels were collected from samples of corn at 2 moisture levels, 11 and 13%, after treatment with the fumigant. Using a dosage of 48 mg/l ^{14}C methyl bromide with a total activity of 2×10^6 DPM and an exposure period of 18 h amounts of residue found in the corn after 4 successive treatments at weekly intervals were measured (Table 1). Radioactivity levels of the residue were determined immediately after each treatment and after 7 days aeration.

TABLE 1: Residues from methyl bromide in yellow dent corn after 5 consecutive treatments at weekly intervals with 48 mg/l of the fumigant and an 18 h exposure period.

Treatment Number	Residue Levels (ug/g corn)[1]			
	Immediately After Treatment		7 Days After Treatment	
1	153.5	150.9	122.6	108.0
2	174.8	171.8	154.3	135.6
3	264.9	226.7	245.5	208.8
4	311.2	319.0	286.2	227.8
5	327.0	325.2		

[1] Data in columns 1 and 3 are for corn of 11% and in columns 2 and 4 of 13% moisture content. Quantities of residue were calculated from No. of DPM found in the sample.

Examination of data from Table 1 shows that some residual fumigant (ranging from 7-28% in different treatments) were lost in the 7 day aeration period. When corn was subjected to repeated treatments, the residue level increased so that more than twice the amount remained after treatment number 5 as compared to the first treatment.

Investigation of the distribution of residue in the corn kernel showed that a large proportion of the labelled material accumulated in the germ (embryo) region of the seed. Quantities found in the endosperm and germ after five consecutive treatments with methyl bromide are shown in Table 2.

TABLE 2. Residue from methyl bromide in endosperm and germ of corn kernels after fumigation at 48 mg/l ^{14}C methyl bromide for 18 h with 5 consecutive treatments at weekly intervals (averages from 12 kernels, based on No. of DPM in the samples).

	Whole Kernel	Endosperm	Germ
Av. Wt. (mg)	280.9	248.7	32.2
Residue per kernel (ug)	77.7	40.2	37.5
Residue per g tissue (ug)	276.6	160.8	1164.6

The data from this test show that although the germ part of the kernel makes up less than 12% of the mass it acquires nearly half of the quantity of residue from the fumigant. On a weight per weight basis the germ tissue contains more than 7 times the quantity of labelled material found in the endosperm. The presence of the high residue in the germ part of the seed could be of significance both from the standpoint of seed germination and in the use of the germ for human or animal food. In food materials its significance will be dependent on the type and quantities of compounds formed as methyl bromide combines with components of the food.

The next phase of this investigation was concerned with the isolation of labelled compounds in the residue to determine their identity and significance. Fumigated corn was ground and extracted with appropriate solvents as the first step towards isolation of the components labelled with ^{14}C. After grinding to a fine powder, the corn was first extracted with ether to remove fat soluble reaction products and was then extracted with solvents to fractionate the proteins. A summary of the activity found in one extraction run (used as an example) is given in Table 3.

TABLE 3. Radioactivity found in extracts from ^{14}C methyl bromide treated corn after extraction with various solvents.

Solvent	Extract	Activity (DPM)[1] Supernatant[2]	Precipitate[2]
Water	67,498	67,736	19,878
0.5 M NaCl	43,821	8,417	31,965
55% 2-Propanol	24,643	2,731	24,756
55% 2-Propanol-0.6% mercaptoethanol	32,085	108	38,571
0.2% NaOH	53,830	13,452	44,201

[1] Total activity in the treated corn after grinding was 236,680 DPM/g and one g was used for the extraction.

[2] Protein in each fraction was precipitated by addition of 25% trichloroacetic acid to a final concentration of 5%. Discrepancies in values between total extract and the supernatant plus precipitate are attributable to differences in procedures for preparation and counting of samples.

From the data in Table 3, it can be seen that radioactive residue is distributed throughout the various fractions (corresponding to albumins, globulins, Zein-1, Zein-2 and glutelin) with a large part in the aqueous extract (amino acids). Negligible activity was found in the ether extract. The proteins separated in these extracts were hydrolysed and the hydrolysates further purified by column chromatography and thin-layer chromatography.

The investigation is continuing to identify the important components of the residue and to determine the quantities of any compounds that may be of significance from the standpoint of human health.

3. **BURPEE, L.L.** and **GAULTY, L.G.** - **Integrated management of turfgrass diseases in Ontario.**

General Objective:

To reduce fungicide requirements for turfgrasses by integrating cultural and chemical strategies for disease management.

Specific Objectives:

1) To evaluate the influence of sulfur and inorganic salts on snow mold disease of creeping bentgrass in the presence and absence of fungicides.

2) To develop a fertilizer-fungicide application program that will result in acceptable control of dollarspot disease using lower than currently recommended fungicide dosages.

Research Summaries:

Specific Objective #1: 1984 represented the third and final year of research for this project. In April, evaluation of field plots revealed that sulfur, applied at 1900 or 3800 kg/ha over a period of 2 years, provided significant ($P = 0.05$) and acceptable control of snow mold on creeping bentgrass. The magnitude of disease suppression provided by sulfur was equal to the control achieved with fungicides containing mercuric chloride or quintozene. Results of controlled environment studies indicate that, in addition to reducing soil pH, sulfur plays a role in enhancing snow mold resistance in turfgrasses. Presently, sulfur is being recommended as a root zone pH modifier for creeping bentgrass. Our results suggest that long-term use of sulfur on turf may reduce the requirement for mercury- and PCNB-containing fungicides that are currently recommended for snow mold control.

Specific Objective #2: Results of preliminary studies conducted in 1983 suggest that the fungicide requirement for dollarspot control on creeping bentgrass can be reduced by applying supplemental nitrogen to turf when symptoms are first observed. In 1984, acceptable disease control (<3% disease) was achieved by applying a total of 60 g/100 m^2) of chlorothalonil on turf that received supplemental applications of sulfur-coated urea (0.5 kg/ha) at 3 wk intervals. In the absence of supplemental nitrogen, 180 g/100 m^2 of chlorothalonil was required to achieve acceptable control. These data indicate that the fungicide requirement for dollarspot control on creeping bentgrass may be reduced 3 fold on turf that receives supplemental nitrogen at the beginning of the dollarspot season.

Results of studies in which low dosages of chlorothalonil (15 g/100 m^2) were tank-mixed with urea (260 g/100 m^2) indicate that urea increases the duration of acceptable dollarspot suppression (ie. the period for which disease is $\leq$3%). Therefore, the ability of turfgrass managers to take advantage of nitrogen-induced dollarspot suppression by applying fertilizer and fungicide simultaneously appears to be quite feasible.

4. BOUGH, M.A. and CAVERS, P.B. - Seed viability, dormancy and overwintering in different populations of proso millet.

Our earlier work has shown that several different biotypes of proso millet occur as weeds in Ontario, and that seeds of many of these do not survive the winter in the soil in large numbers. In fact, seeds of some biotypes do not have any obvious dormancy mechanisms. Nevertheless many biotypes of this annual grass are able to persist as weeds and some cause serious infestations in Ontario.

Using a range of biotypes, experiments have been conducted or are currently in progress to try to pinpoint some of the reasons for proso millet's success.

Under investigation are: (only (a) is complete)

(a) The size of any persistent seedbanks in the soil: Large numbers of seeds of only the black-seeded biotype were present in the soil by mid-July, thus there is no appreciable long-term seed bank in Ontario for the 'crown' and 'golden' populations studied.

(b) The rate of deterioration of seeds in the soil overwinter, the role of seed borne fungi in this process and the effect of conditions to which seeds are subsequently transferred: On the two month's data available differences in survival depend on the depth of seed burial. There are also between-biotype differences.

(c) Dormancy mechanisms in the seeds: Temperature and stratification treatments conducted in both light and dark have provided sufficient data after 2 months to suggest wet stratification and darkness as dormancy breakers for black-seeded proso millet; or alternatively light as a germination inhibitor. To a lesser extent this may be true for 'crown' and 'golden' seeds too.

5. CHAPMAN, R.A. and HARRIS, C.R. - Persistence and degradation in soil of insecticides recommended in Ontario for corn rootworm control.

In the second year of this study, the persistence of 14 treatment-material combinations was evaluated under field conditions. Chlorfenvinphos, chloethocarb, and CGA73102, which had shown limited persistence in 1983 were not included in 1984. Fensulfothion, trimethacarb, and two experimental insecticides were added to the list of seven insecticides carried over from 1983. Comparison of persistence data for those insecticides tested showed that all materials were less persistent in 1984. Climatic conditions appear to be a factor and microbial adaptation also is being examined. The re-

treated carbofuran soil was known to be adapted to degrade carbofuran but carbofuran degradation in previously untreated soil was equally quick. Isofenphos, the most persistent insecticide tested in 1983, was the least persistent of the insecticides tested in 1984 and further examination revealed that soil adaptation had occurred.

Laboratory studies were conducted to determine: the extent to which cross-activity to other insecticides occurred with carbofuran- and fensulfothion-activated soils; and the factors influencing the development of carbofuran-activated soil and the rate of carbofuran degradation in activated soil.

Sandy loam collected at two different dates (November/82, October/83) was activated with four different carbofuran treatments and tested for cross-activity to 10 methyl carbamate insecticides as well as butylate, EPTC, and chlorpropham. Carbofuran-activated soil showed cross-activity to nine of the 10 methyl carbamate insecticides, but not to the three herbicides. Activity varied with soil collection date and activation treatment.

Sandy loam activated by two different carbofuran treatments was examined for cross-activity to a number of corn rootworm insecticides. No effect was observed against fonofos or isofenphos. There was slight activity against phorate, disulfoton and terbufos at the higher level of carbofuran activation. Disappearance of chlorfenvinphos, diazinon, fensulfothion, and chlorpyrifos was retarded slightly in carbofuran-activated soil.

Sandy loam activated by fensulfothion treatment was examined for cross-activity to 19 OP and carbamate sulfides and their sulfoxide and sulfone metabolites. Soil was only active for fensulfothion sulfide and sulfone in addition to the parent.

The effect of four treatment levels (10, 1, 0.1, 0.01 ppm), four soil types (sand, sandy loam, sandy clay loam, muck), seven moisture levels (air-dry to 80% MHC), three temperatures (3^{o}, 15^{o}, $28^{o}C$), and three insecticide formulations (analytical, granular, flowable) on the development of soil microbial adaptation to carbofuran degradation was examined. All were important factors. Activation rate was dependent on soil type. Adaptation did not occur at 10% MHC or in air-dry soil or in soil at $3^{o}C$.

The effect of seven moisture levels and three temperatures on the activity of carbofuran-adapted microorganisms in sandy loam toward carbofuran was examined. Activity was present at 10% MHC but not at 5%. Activity continued at $3^{o}C$. In another study, the activity of carbofuran-adapted and an unadapted soil toward analytical and granular carbofuran treatments was compared at 25 and 60% MHC. Activity toward the granular formulation was strongly moisture dependent, eg. no difference in degradation rate between adapted and unadapted at 25% MHC but a large difference at 60% MHC. Activity toward analytical material was relatively independent of moisture level.

The effect of retreatment at various levels on the activity and cross-activity to two other methyl carbamates (chloethocarb and oxamyl) increased with repeated carbofuran-treatment while activity toward carbofuran remained about the same. Adaptation to carbofuran persisted for at least 26 weeks following a single 10 ppm treatment.

Results obtained thus far suggest the following conclusions:

1. Climatic conditions appear to have an important role in moderating corn rootworm insecticide persistence in soil.

2. Microbial adaptation for rapid degradation of methyl carbamate (carbofuran, chloethocarb) and organophosphorus (fensulfothion, isofenphos) insecticides in soil has been demonstrated in laboratory and/or field studies.

3. Carbofuran-adapted soil microorganisms can metabolize other methyl carbamate insecticides but activity against organophosphorus insecticides is limited.

4. Insecticide formulation and concentration and soil and climatic conditions influence the rate at which soil microbes will adapt to degrade carbofuran in soil and also influence the rate of carbofuran degradation in activated soil.

5. No evidence has been obtained to date of microbial adaptation to chlorpyrifos, disulfoton, fonofos, phorate, or terbufos.

6. VALDES, E. and EDGINGTON, L.V. - Biological and chemical control of onion white rot in muck soil.

One of the main objectives of this research was to evaluate the role of Sporidesmium sclerotivorum as a biocontrol agent of Sclerotium cepivorum, a pathogen of onions, when used in combination with fungicides in muck soil.

Dicloran, iprodione and vinclozolin applied as soil drenches gave some control of the disease under conditions of high inoculum pressure (0.5 sclerotia/g soil).

The Sporidesmium sclerotivorum isolate used was not effective as a biocontrol agent of Sclerotium cepivorum since the population of sclerotia remained constant during the season in the plot treated with S. sclerotivorum and in the untreated plot. Future studies will be carried out to determine the potential of four new S. sclerotivorum isolates to control S. cepivorum.

The initial results obtained from an experiment in which onions are rotated with carrots during three seasons, indicated that the population of sclerotia declined significantly in the carrot plot when compared to the onion plot. This study will be continued during the 1985 season.

7. ELLIS, C.R., McAUSLANE, H., and BEATTIE, B. - Development of suitable monitoring methods and economic thresholds for corn rootworms.

a) Development of suitable monitoring methods and economic thresholds for corn rootworms (C.R. Ellis and H. McAuslane)

This is the first report on this project which is expected to take several years to complete. Progress on the two parts of the project, namely the monitoring methods and the thresholds is discussed separately.

Considerable information has been published on monitoring methods for corn rootworms in field corn. Unfortunately, we do not know which method of monitoring is most suitable to our Ontario conditions in terms of equipment, cost, time required, and reliability of the prediction for the two species of rootworms. In 1984, six methods of monitoring were compared; yellow sticky tags, yellow sticky cylinders, yellow sticky boards, whole plant counts, ear-zone counts, double-cone pheromone traps, and pheromone 1c traps baited with western corn rootworm (WCR) pheromone. Of the sticky traps, the cylinders had the least variation in beetle numbers per monitored field and were less costly than the boards. Ear-zone counts selectively trapped northern corn rootworms (NCR) over the WCR. Thus, although this method of monitoring is widely used in the corn belt, it will be difficult to apply with the mixed populations that occur in Ontario. The pheromone-baited, double cone traps caught too few adults to be useful. Pheromone 1c traps caught many beetles and may be useful in monitoring. Analysis of costs and reliability is not complete at this date.

Research will continue next year on only one or two of the most promising methods of monitoring and attention will be given to the best time to make estimates and also to sequential sampling as a way of reducing costs without sacrificing reliability.

Because this is the first year of the project, we do not have data on the economic threshold this year. As outlined in the research proposal, the numbers of beetles were monitored in 30 corn fields four times during August and early September. Next year the yield of grain corn both with and without insecticides for rootworm control will be compared in these 30 fields. This data will provide the first estimates of the beetle populations that result in losses the following year. In 1984, monitoring was done by counting the numbers of WCR and NCR per whole plant on five

plants in each of five areas spread over each field. The areas and plants sampled were recorded in sequence so that the data can be analyzed using 1, 2, 3, 4, or 5 plants per location and various numbers of locations within the field. This analysis will provide data on optimizing sampling effort within fields. This preliminary data will be used in 1985 to develop sequential sampling schemes.

b) Drift of granular insecticide used for control of corn rootworms (C.R. Ellis and B. Beattie)

A large percentage of the granular insecticide used in Ontario is for control of corn rootworms in field corn. Insecticide used for this purpose is applied in a 15-cm band along the corn rows at planting time. A survey in 1983 showed that only 10% of the equipment used to apply granular insecticides to field corn had wind guards to protect from drift although the use of wind guards is recommended by the Ministry of Agriculture and Food. Because of the amount of granular insecticide used in field corn, because of the 15-cm wide target, and because protection against drift is generally not used in Ontario, the significance of drift of insecticides applied for control of corn rootworms was investigated in 1984. This particular research was sparked, in part, by the large increase in the number of cases of poor rootworm control with insecticides in 1984 and the observation that it was much windier than normal in May when the corn was planted.

Dyed granular insecticides were dropped in a wind tunnel from four heights (7.5, 15, 22.5, and 30 cm) with four wind velocities (0, 10, 20, and 30 kg/hr). The material was collected on lined graph paper (1/10 inch grid) which was smeared with vaseline and placed on the floor of the tunnel. The granules were counted in each 1/10 inch. The mean linear distance for 50% deposit of granules was calculated. Each treatment was replicated at least twice.

As expected, the greater the wind the greater the amount of drift, and also the higher the insecticide drop the greater the drift. Results showed that lowering the spreaders from 15 cm to 7.5 cm above the ground reduced the amount of drift by about one-half. However, even when spreaders are close to the ground, there is considerable drift under windy conditions. For instance, when dropped from 7.5 cm the insecticide drifted an average of 10 cm under 30 kg/hr winds at ground level. Formulae developed by the Department of Land Resource Science were used to calculate expected wind speeds near the ground. Wind speeds near the ground in the area where granular insecticides are dropping are approximately one-half those reported by weather stations at 10 m above ground.

Results demonstrated that drift (10 to 20 cm) can occur under windy conditions and can be a factor causing poor control. Drift of a few centimeters can mean that roots on one side of the corn plant are not adequately protected. The roots lost in this instance are those roots that are most important in holding up the corn plant when winds from the same direction occur later in the season. Results also showed that the insecticide can be spread over too wide an area so that the effective rate per unit area (calculated for a 15-cm band) is too low.

Research on the application of granular insecticides is continuing.

8. HOWARD, A.M. and GILLESPIE, T.J. - A field guide for surface wetness duration measurement.

Surface wetness duration (SWD) is the length of time that rain or dew is retained on foliar surfaces. This moisture is a critical factor in the development of certain plant diseases whose spores require a favourable combination of temperature and SWD for infection of tissue. The field monitoring of SWD is thus important to plant disease research and to the scheduling of disease control measures.

With the support of the Ontario Pesticides Advisory Board and other agencies, cooperative research in the Departments of Land Resource Science and Environmental Biology at the University of Guelph has developed guidance for rational fungicide spray scheduling in carrots and onions. In the course of these investigations we developed and tested some instrumentation for the measurement of SWD. Thus we have acquired a good deal of experience with the subject of surface wetness duration measurement which we felt was worth collecting into a Field Guide for the information of other researchers, extension personnel, and growers.

The Field Guide contains two main sections: Mechanical Instruments and Electrical Resistance Sensors. In the first section we discuss the hygrothermograph and the De Wit recorder which use hair or string made from organic fibres as sensors. The hygrothermograph responds only to relative humidity while the De Wit responds to both humidity and liquid wetness. This response makes them most suitable for work with diseases that react to relative humidity and interferes somewhat with their ability to monitor SWD alone. We also briefly mention the Taylor Recorder which utilizes a moisture-sensitive pencil to mark a glass plate. It has been used with partial success in other countries, but not in Ontario. The section on Electrical Resistance Sensors begins with consideration of devices which clip onto real plant parts. These require considerable care and maintenance so are not suitable for grower use, but are nonetheless an important research technique. Mock leaves made from plates or cylinders which change

their electrical conductivity with the deposition of liquid water are next discussed. These have been successfully used in operational pest management schemes and in conjunction with microprocessor-based systems that process data on some or all of temperature, humidity, SWD, and rainfall, to identify disease infection periods.

The Field Guide is by no means exhaustive, but covers a representative cross-section of the different types of instruments that have been used to monitor SWD. There are numerous versions of these instruments which operate on the same principles but vary somewhat in construction. When selecting a system to monitor surface wetness, it is important that the user take into account the advantages and limitations of the various instruments and sensors. There is no "perfect" wetness duration sensor. It is hoped that the Field Guide will help readers gain an understanding of each instrument that will lead them to the best choice of SWD sensor for their particular purpose.

The Field Guide will be available at cost as Technical Memo 85-1 from the Department of Land Resource Science, University of Guelph, Ontario, N1G 2W1.

9. HUBBES, M. and SMITH, S.M. - Feasibility of using the egg parasite, Trichogramma minutum for biological control of the spruce budworm.

Maximum parasitism of fresh egg masses of Choristoneura fumiferana was 16% and 87%, in forest stands, following release of 480,000 and 12 million T. minutum females/ha, respectively. Releases at intervals of one week sustained parasitism. Horizontal dispersal by Trichogramma minutum was less than five meters under forest conditions and was influenced by wind direction. The most significant factors affecting the level of egg mass parasitism were the synchrony of the release with the oviposition of the host, the density of the parasitoids, and the weather conditions. Food supply to the parasitoids, vertical location of the host eggs in the stand, intensity of solar radiation, and density of the host were less important. Parasitism was not affected by the tree species on which eggs were laid. Sixty per cent parasitism on natural egg masses of C. fumiferana results in an 80% reduction in overwintering second-instar larvae.

Isoenzyme patterns, biological characteristics, and parasitism in the field were compared for seven strains of T. minutum Riley. Patterns of 16 enzyme systems were described using starch gel electrophoresis. Seven of these were used to differentiate strains of parasitoids. Electrophoretic keys, based on genotypic relationships, were developed to predict parasitism in the field. The rate of increase (r_i) was not considered a good criterion for determining parasitism in the field.

Isoenzyme patterns were not affected when parasitoids were reared at 13°C or 27°C but additional bands appeared when parasitoids were reared on Sitotroga cereallela compared to C. fumiferana. Strains of parasitoids were more fecund and lived longer when raised on C. fumiferana compared to Ephestia kuehniella although their rate of increase was higher when parasitizing the same species of host on which they had been reared. Parasitoids reared at temperatures below 17°C had lower fecundity on the first day of emergence, lower total fecundity, and reduced longevity than those reared at temperatures above 17°C. The mean thermal constant and developmental threshold, for all strains, over all rearing temperatures, were 149.8°D and 10.5°C, respectively.

Based on the results of the present study, it was concluded that factors influencing inundative releases of T. minutum could be manipulated to improve parasitism and that the use of T. minutum was feasible for the control of forest defoliating Lepidoptera such as the spruce budworm.

10. DAY, K. and KAUSHIK, N.K. - Studies on the toxicity of fenvalerate to filter-feeding zooplankton in an aquatic system.

Fenvalerate (α-cyano-3-phenoxybenzyl-2(4-chlorophenyl) isovalerate) is a synthetic pyrethroid currently registered for the control of a number of agricultural pests. In addition to high insecticidal activity, moderate persistence and low mammalian toxicity, it has been found to be extremely toxic to many non-target organisms, especially those found in the aquatic environment.

Laboratory and field experiments were conducted during the summers of 1983 and 1984 to determine the toxicity of fenvalerate to filter-feeding freshwater zooplankton. In July and September of 1983, a large volume (125 m^3) in situ enclosure installed in Lake St. George, Ontario, was treated with a surface application of fenvalerate (EC 30% a.i.) in order to achieve nominal concentrations of 0.1 and 0.01 ug L^{-1}, respectively. One similarly-sized enclosure remained untreated as a control. During the summer of 1984, a series of enclosures were treated in triplicate with surface applications of fenvalerate to give nominal concentrations of 0.03 and 0.01 ug L^{-1}, respectively. Six enclosures remained untreated and served as controls. In order to determine if the emulsifier in the EC formulation contributed to toxicity, one additional enclosure received a surface application of the emulsifier blank equivalent to treatment with 0.05 mg L^{-1} fenvalerate. Results indicated that concentrations of 0.1 and 0.05 ug L^{-1} fenvalerate had a significant effect on cladocerans and caused a reduction in numbers of organisms. Calanoids were not similarly affected. A concentration of 0.01 ug L^{-1} fenvalerate and the emulsifier blank had no significant effect on zooplankton.

Under laboratory conditions, the filter-feeding activity of several species of zooplankton was used as a physiological index to determine the effect of low concentrations of fenvalerate and the emulsifier blank. Exposure to a series of concentrations of the pesticide (0.001 - 0.5 ug L^{-1}) for 24 hr resulted in differential toxicity to three species of zooplankton. The emulsifier blank had no significant effect on all three species of zooplankton at concentrations equivalent to the highest concentration of fenvalerate (ie. 0.5 ug L^{-1}).

The effect of particulate matter in the form of algal cells on the toxicity of fenvalerate to filter-feeding zooplankton was examined under laboratory conditions. The uptake of radioactively labelled (14-Carbon) fenvalerate by Daphnia galeata mendotae was not significantly different in the presence of a range of algal cells (5.0×10^3 to 1.0×10^5 cells ml^{-1}).

11. MAKEY, S. and LEILI, H. - Weather-timed fungicide spraying for disease control in tomatoes.

F.A.S.T., a forecast system for Alternia solani (Early Blight) on tomatoes, was used as the basis for the timely application of fungicides. This system, modified by Dr. Ron Pitblado of the R.C.A.T., incorporated daily environmental parameters of temperature, rainfall, relative humidity, and hours of leaf wetness, into a daily disease severity index (D.S.I.). Fungicide applications were scheduled in sequence with the daily accumulation of this index.

The weather timing of fungicidal applications was tested on tomatoes, at 2 locations in Essex County. Very dry weather conditions occurred at each location, and as a result, both accumulated low D.S.I. levels (96 for Location 1, and 74 for Location 2).

At Location 1, the weather conditions were conducive to the development of foliar disease. At the same time, the disease pressure was insufficient to contribute to the development of Anthracnose, or adversely affect field yield. However, some fungicide applications were necessary for the control of foliage disease (Early Blight).

Due to unusually dry conditions at Location 2, the index accumulation was slow to develop. As a consequence, several spray programs were delayed until the indexes of 35 and 45 were reached, late in the growing season. The delay of these initial sprays resulted in comparable foliage disease control, and equal field yield to that of the commercial spray program, but provided poor Anthracnose control.

Adequate disease control was obtained this year, using fewer sprays than commercially recommended. This is what the F.A.S.T. system indicated during this drier than normal growing season. Further research will be required to determine the effect of different weather conditions on the spray programs.

12. MACHADO, V.S. and ALI, A. - Efficacy of alternative herbicides to allidochlor in onions.

Recent action by the Ministry of the Environment in response to Federal legislation relating to the Industrial Bio-Test Laboratory issue, had led to the imposition of a Permit system for a limited period, to control the use of allidochlor on onions grown in muck soils. Replicated field trials to evaluate alternative broadleaf herbicides to eventually substitute for allidochlor, were carried out at the Muck Research Station at Bradford. Earlier results of this program indicated that cyanazine, pendimethalin and oxyfluorfen were promising candidate broadleaf herbicides, during early postemergence up to the 3 fully developed onion leaf stage. Sethoxydim and fluazifop proved effective for grass weed control. An in-depth study of the tolerance of onion seedlings to oxyfluorfen, positively correlated seedling tolerance to the gradual development of epicuticular wax on the onion leaf surface, until satisfactory crop tolerance was noted at the 2 leaf stage.

The 1984 program focussed attention on the effectiveness of oxyfluorfen, pendimethalin, CIPC and propachlor as pre- and early postemergence herbicides, as well as documenting the weed flushes from planting up to the 2 leaf onion stage. Oxyfluorfen, CIPC and propachlor were each tested as pre-emergence herbicides, in combination with early postemergence applications of pendimethalin or CIPC alone or together, at the loop and early 1 leaf onion stage. Broadleaf weed control up to the 2 leaf onion stage was very good with propachlor as a pre-emergence treatment, and recorded harvest onion yields equivalent to 100% of the hand weeded 'check' plot. Results with oxyfluorfen and CIPC pre-emergence, recorded relative yields of 81% and 93% of the check plot, respectively. Five sequential weed flushes were recorded during the 1984 season, from onion emergence up to the 2 leaf onion stage, when the weed canopy was disturbed through the use of herbicides. Onion samples were collected for residue analysis by the OMAF Pesticide Residue Laboratory, to support future federal registration. A minor trial to evaluate the competition of barley wind abatement rows with onions, indicated that onion yields were drastically reduced if the barley was not eradicated with fluazifop, after 6 weeks from planting.

13. STEMEROFF, M. and MADDER, D.J. - The economic returns to integrated pest management on apples in Ontario.

In Ontario, IPM has been implemented in apple orchard production since 1969. This has required the investment of resources by Agriculture Canada, the University of Guelph, Ontario Ministry of Agriculture and Food, Ontario Ministry of the Environment, and apple producers for the development, implementation, and maintenance of this IPM program. This study was undertaken to quantify the economic returns to this investment.

Conventional cost/benefit analysis was employed to identify the economic returns to IPM. The analytical model was developed and simulated using Lotus 1-2-3, (an electronic spreadsheet). All results are quoted in constant 1982 dollars, thus accounting for inflation. Analyses were performed using the OMAF crop production guide as the standard against which the three levels of IPM currently in use in apples were compared. The three levels of IPM currently in use are: regional monitoring, intensive monitoring with a portion of the orchard scouted and custom monitoring with the entire orchard scouted. Results indicate the following:

1. The costs of research, extension and monitoring for apples in Ontario amounted to $14.4 million during the period of 1965-1984. Of this total cost, research accounted for 65%, with extension and monitoring accounting for 35% of the total.

2. The quantifiable benefits from IPM (reductions in pest control costs, ie. insecticide, fungicide, acaricide, and associated application costs) during the period of 1965-1984 were $58.5 million.

3. Research, extension and monitoring costs of IPM on apples have varied from year to year from $0.2 million to $1.2 million with greatest costs occurring in 1981.

4. Benefits from IPM on apples have steadily increased from nil in 1969, to $2.4 million in 1977, and $7.0 million in 1984.

5. The ratio of benefits to costs from IPM on apples in Ontario ranges from 3.3 to 4.1 depending upon the discount rate used. This indicates that investment in IPM has yielded substantial monetary benefits.

6. It is generally acknowledged that the use of IPM results in additional benefits that are difficult to quantify including: reduced pesticide burden in the environment; delayed development of pesticide resistance by pests; reduced occupational exposure to pesticides; and increased stability of crop production.

14. MADDER, D.J. and STEMEROFF, M. - The feasibility of integrated pest management on potatoes in Ontario.

The intensive use of pesticides to control the insect, pathogen and weed pests of potatoes has resulted in some deleterious effects. The implementation of IPM programs on other crops in Ontario has led to increased efficiency of pesticide use, reduced risk from pest damage, and improved grower awareness of alternative control methods. This study was undertaken to ascertain the feasibility of implementing an integrated pest management program on potatoes in Ontario. The results of the study indicate that:

1. The greatest potential for an IPM program in potatoes to increase the efficiency of pesticide use and reduce risk from damage is in insect control. Currently, growers use either granular and/or foliar-applied insecticides to control insects. Monitoring techniques and some economic thresholds currently exist for the major insect pests. If these techniques are tested and found to be valid under Ontario conditions, insecticides would only be used when necessary, and the current practice of applying a granular insecticide at planting may be reduced or eliminated. In addition, current research on biocontrol (parasites), and cultural control techniques (use of resistant varieties and altering time of harvest and planting) suggest that alternatives to intensive insecticide use may be feasible although these must also be tested under practical field conditions. An IPM program would provide the structure to help implement these alternatives to insecticides.

2. The most significant diseases attacking potatoes are early and late blight. Disease monitoring systems (eg. Blightcast) used in other potato growing regions have rarely resulted in the reduction of fungicide use. However, the scouting of fields would help identify disease foci, and aid in the timing of the initiation of fungicide applications. The most likely other means of reducing fungicide use is the introduction of resistant varieties that are acceptable to the market.

3. At the current time, no viable alternative exists to the reliance on herbicides for weed control. The implementation of an IPM program would have little effect on the weed control technology used by growers. An IPM program could provide weed identification services and long range weed control planning.

4. Economic thresholds for nematodes in potatoes are established. However, difficulties in the logistics of the sampling required to use these thresholds and the high cost of the only control method currently available, (ie, nematicides), often negates the use of control measures for nematodes in potatoes.

5. On the basis of currently available technology, a pilot IPM program focussing on increased insecticide efficiency is feasible, although monitoring and economic thresholds would have to be thoroughly tested prior to their use in growers' fields.

15. McLEOD, D.G.R. and TOLMAN, J.H. - Losses in production of processing tomatoes and cabbage attributable to insects, diseases and weeds.

In order to verify 1983 yield losses in processing tomatoes and cabbage, separate trials were again set up at two locations in the London area. For both crops, the six treatments (IFH, IFHoe, FH, IF, IH, O) were replicated four times in a randomized complete block design.

Tomatoes

Heinz 1350 tomatoes were transplanted into a loam soil adjacent to the Fanshawe Field Station on June 8. Although feeding damage by tomato hornworm, Manduca quinquemaculata, was observed, problem insect infestations did not develop and no insecticides were applied. Ground cover by weeds, although initially somewhat uneven, averaged 55% in herbicide-free plots within six weeks of trial initiation. Dominant weeds, in order of importance, were old witchgrass, lamb's-quarters, ragweed and pigweed. Excellent initial weed control followed incorporation of trifluralin + metribuzin at a cost of $75.27/ha; row cultivation plus manual weeding ($3.85/hr) boosted the total cost of weed control in herbicide-treated plots to $316.78/ha. Weed control utilizing only row cultivation and manual weeding cost $632.67/ha). Very low infestations of Septoria leaf spot and bacterial speck were observed on older foliage by early August. A devastating hailstorm on August 18 totally destroyed the trial prior to harvest.

Cabbage

Little Rock cabbage were transplanted into a sandy clay loam near Hyde Park on June 5. Cabbage aphid, Brevicoryne brassicae, appeared in the trial in mid-June; populations peaked on July 3 when 30% of plants in insecticide-free plots were infected. Significant feeding damage by imported cabbageworm, Artogeia rapae, was observed in all plots by July 16. Injury increased steadily in insecticide-free plots, reaching a peak on August 6 when 72% of plants showed fresh feeding damage. High populations of crucifer flea beetle, Phyllotreta cruciferae , caused only surface scarring of wrapper leaves while peak populations of cabbage maggot, Delia radicum developed too late in the season to affect well established root systems.

Weed populations proved somewhat uneven. Dominant weeds were lamb's-quarters and pigweed while a high population of domestic buckwheat infested one replicate. Post transplant application of chlorthal dimethyl + metolachlor at a cost of $242.46/ha provided very effective early season weed control; supplementary row cultivation followed by hoeing raised the total cost of weed control in herbicide treated plots to $515.93/ha. Weed control by row cultivation and hoeing only, cost $1284.09/ha.

Black leaf spot caused by Alternaria first appeared in early August.

Delayed fungicide application resulted in disease spread throughout the trial.

Cabbages were cut and graded on September 6. Results were as follows:

SOURCE OF LOSS	PROGRAM APPLIED	AVERAGE MARKETABLE YIELD (tonnes/ha)	%[i] YIELD LOSS	VALUE PER HECTARE ($56.86/t)	LOSS PER HECTARE ($)
-	IFH[ii]	34.78	-	1977.59	-
-	IFHoe	31.22	10.41	1775.17	202.42
Insects	FH	17.89	48.56*	1017.22	960.37
Weeds	IF	21.22	38.98*	1206.57	771.02
Diseases	IH	35.96	+3.39	2044.69	+67.10
In,W,D[iii]	O	8.58	75.33*	487.86	1489.73

* - $p<0.05$
i - loss relative to complete IFH program
ii - I-insecticide; F-fungicide; H-herbicide; Hoe-cultivation + hoeing; O-none
iii - In-insects; W-weeds; D-diseases

Failure to control insects or weeds significantly reduced cabbage yields. The value of higher yields in treated plots was at least twice the cost of either insecticide ($446.50/ha) or herbicide ($242.46/ha) application. Black leaf spot did not affect the fresh yield from fungicide-free plots but may well have affected long term storability of cabbage from those plots.

16. **BIGGS, A.R. and NORTHOVER, J. - Etiology and host resistance to brown rot of stone fruits in the Niagara region.**

Field experiments were conducted with peach to ascertain the relative importance of various sources of overwintering Monilinia fructicola inoculum during the blossom period. Four sites with three varieties per site were monitored weekly immediately before, during and after blossom for apothecia, sporulation of mummies in the tree and on the ground, sporulation on old cankers, fruit pedicel infections, and necrotic twigs, and incidence of blossom infection. Blossom infection was negligible in 1984. Tree mummies were active sources of inoculum during the bloom period, whereas only a low percentage of mummies which overwintered on the ground supported spore production. Mummies from the variety Candor showed a higher percent of sporulating mummies compared to Redhaven and Cresthaven.

Inoculum sources were followed over the summer to assess the relative importance of blossom infections, aborted fruit, thinned fruit, and insect injuries as contributors to a potential brown rot epidemic. Blossom infection and insect injuries did not contribute to summer inoculum levels in 1984. If fruit were thinned at pit hardening or later, they became infected on the orchard floor and served as sources of brown rot spores. Infection and sporulation on aborted fruit hanging within the tree is reported for the first time in Ontario and may constitute an important source of inoculum carry over and build up from spring into mid- and late summer.

Laboratory investigations focused on the relative susceptibility of Ontario stone fruit species with particular emphasis on the influence of host genotype on epidemiological characters associated with pathogenic fitness. Seven varieties of sweet cherry, ten varieties of peaches, and eleven varieties of plums were assessed for colonization rate, spore production, and latent period. Data from peach fruit showed that early maturing varieties supported greater spore production than those maturing later. A similar relationship for sweet cherry and plum fruit was not apparent. Differences in epidemiological characteristics in stone fruit varieties suggest that breeding for disease resistance is feasible. Where disease resistance is incorporated, fewer fungicide sprays would be needed to achieve the desired level of control.

17. **PREE, D.J. - Status of pesticide resistance in the spotted tentiform leafminer and European red mite in apple growing regions of Ontario.**

Tentiform Leafminer

Low levels of resistance (4-6x) to the synthetic pyrethroids, permethrin and fenvalerate, were shown in field collected moths in 1983. Further

laboratory tests have shown that resistance extends to all synthetic pyrethroids, including several not yet field tested. High levels of resistance to DDT suggest that the rapid development of resistance to synthetic pyrethroids might be due to previously selected resistance to DDT. Surveys of populations from selected orchards across southern Ontario indicate that resistance is most common in the Simcoe area, has become prevalent in the Bowmanville-Smithfield area, and is less common elsewhere. Resistance levels were slightly higher in the Bowmanville area (9x vs 4-5x) than in the Simcoe area. However, the mechanism of resistance (likely a target site change or kdr type) is probably similar. All populations from commercial orchards retained high levels of resistance to azinphosmethyl. Where high numbers of resistant leafminers were found, growers were advised to switch to methomyl, a carbamate insecticide. Other current research indicates that an adjustment in spray timing to maximize effects of synthetic pyrethroids may still allow their use against resistant populations.

European Red Mite

In the laboratory, populations of European red mite obtained from a commercial apple orchard in Niagara in 1982 showed ca. 10x resistance to cyhexatin. Resistance to dicofol in another population was ca. 15x. Cyhexatin resistance is probably inherited as semidominant, whereas dicofol resistance appears due to a single recessive gene. In a survey of 45 commercial orchards, 27% showed evidence of cyhexatin resistance, whereas only 4% had dicofol resistant populations. None showed resistance to both miticides simultaneously. Growers are advised, as a general rule, to rotate application of cyhexatin and dicofol. Current research indicates that cyhexatin resistant mites may be at a reproductive disadvantage and that reversion to susceptibility may take place.

18. SANDERS, C.J. - **Development of sex attractant traps for monitoring changes in low density spruce budworm populations as a means for implementing early intervention management strategies.**

Sex pheromone traps are ideally suited for monitoring changes in density of sparse populations, and the original objective was to develop their use for monitoring low density spruce budworm populations to provide early warning of impending outbreaks. With the advent of high capacity traps in 1982, the objective was extended to include their use for estimating numbers over a wider range of population densities.

A "home-made" trap design was tested in 1982 which gave a regression coefficient of 62% when the 1982 moth catch was plotted against 1983 larval counts. Trapping was repeated in the same plots in 1983, giving a regression

coefficient of only 21% between 1983 moth catches and 1984 larval counts. Recognizing that a commercial trap would be more appropriate for extensive surveys, several commercial designs were evaluated both in a laboratory wind-tunnel and in the field. Highest efficiency (percentage of the attracted moths which were captured and retained) was obtained with the 'Uni-trap' from Insect Pheromone Systems (UK). In 1984 a Canadian made trap with similar attributes to the Uni-trap has come onto the market, and this is now being recommended for operational use.

Meetings were held in November 1984 with potential users in the CFS Forest Insect and Disease Survey, the Quebec Department of Energy and Resources, and State and Private Forestry, USDA Forest Service. Reaction to the use of the trap was favourable, and an operational trapping program will start in 1985. Traps will be deployed in some 500 locations in eastern Canada and several hundred locations in the adjacent states.

19. SANDERS, C.J. - Development of sex attractant traps for monitoring Jack pine budworm fluctuations.

In 1984 an attractant for Jack pine budworm was identified in a cooperative venture between the New Brunswick Research and Productivity Council and the Ontario Ministry of Natural Resources, paving the way for the development of a sex pheromone monitoring program for this species. In a cooperative project with the Michigan Department of Natural Resources, baited traps were deployed in over 30 locations in Michigan. A considerable range of catches was obtained, but correlations will have to await larval sampling in 1985. In Ontario a range of different concentrations and blends of the four components of the attractant were tested to try and maximize attraction. Catches were well below those obtained when using virgin females as bait, suggesting that important components are missing from the existing attractant, and therefore further chemical analysis of the natural pheromone is required.

20. SEARS, M.K. - Crop loss associated with pests of canola in Ontario.

The impact of insect, weed and disease pests of canola was evaluated in a plot trial at the University of Guelph in 1984. The major pests considered in this experiment were the crucifer and the striped flea beetle, annual broadleaf weeds and grasses, and seedling blights and white mold. The impact of each group of pests on the plots of canola was regulated by four levels of pesticide use (eg. 10 = no insecticide use, 11 = a granular insecticide treatment at planting, 12 = a foliar applied insecticide treatment after seedlings became established, 13 = a combination of granular and foliar

insecticide treatments, and a similar series of herbicide and fungicide treatments). The four levels of treatments for each pest group were combined in a factorial experiment which produced 64 different combinations of treatments. These were replicated twice in a randomized block design for a total of 128 treatment plots.

Measurements of damage (insect damage, disease incidence, and weed density), plant growth (fresh weight, rate of growth, plant stand) and yield (no. racemes, no. pods, seed weight, gross yield and seed quality) were recorded at appropriate times during the season. A substantial infestation of crucifer flea beetles occurred during the seedling stage and a second generation was abundant during pod formation. Weed density was not homogenous within the plots as a result of the herbicide treatment applied the previous season. Little or no disease incidence occurred in the seedling or pod formation stages despite the effect of periodic sprinkler irrigation. Analysis of variance performed on all parameters indicated that the main effect on yield for each of the 3 pest groups was significant only for insecticide treatments. Interaction among the pesticide groups was not significant.

Plots receiving insecticide treatments produced seed yields in direct relationship to the amount of insecticide applied (ie. 10 = 1.7 t/ha, 11 = 2.1 t/ha, 13 = 2.5 t/ha). When the value of gross yield (@$330/tonne) and production costs (basic costs = $512/ha w/o treatments) for each of the insecticide treatments were estimated, plots receiving the combination of insecticide treatments (13) returned the greatest margin at $268/ha ($122/a), plots receiving only granular or foliar treatments returned $160/ha ($73/a) and $151/ha ($69/a), respectively. The nontreated plots returned $26/ha ($12/a). Loss of yield due to insect damage in these instances reduced the return on investment by 83-90%.

21. SIDDIQUI, Z. - Environmental fate analysis of pesticides after application in buildings for structural pest control.

Diazinon is a commonly applied insecticide to buildings for structural pest control. Field experiments were initiated to determine the fate of diazinon after application in buildings for german cockroach control. The study was conducted in two types of buildings: (i) highrise apartments, and (ii) single detached houses. Two types of spraying patterns: (i) fan spray, and (ii) crack and crevice treatment, were evaluated by using a compressed air B & G sprayer. A spraying solution of 1% diazinon in water was prepared by mixing Sanex Diazinon 50 E @ 20 ml/litre of water. At the time of treatment the entire building was treated under a total clean-out program for cockroach control.

Air sampling was done at the following intervals: before spraying, during spraying, 2 hours, 6 hours, 1-day, and 3-days after spraying. A Nutech model 221 AC/DC gas sampler (property of the Ontario Ministry of the Environment) was used. Air samples were adsorbed on 5 cm of Supelco Florisil PR 60-100 mesh in a 10 cm tube at 5 litres/min for one hour at each sampling time. The air temperature was also recorded.

Two samples were collected for each sampling interval, spraying pattern and building type. Diazinon residues will be determined by gas chromatography.

22. SIDDIQUI, Z. - Meadow mouse control in apple orchards.

Studies were initiated in 1981 to evaluate a poisoned bait station for long term meadow vole control in Ontario apple orchards. Five rodenticides (0.005% bromadiolone, 0.001% brodifacoum, 0.005% chlorophacinone, 2% encapsulated zinc phosphide and 2% zinc phosphide on cracked corn) in the bait station were compared with the conventional broadcast method using 2% zinc phosphide on cracked corn. Baits were maintained in the bait station throughout the year, while the broadcast treatment was done once in fall only. Four orchards were selected for the study and each treatment was replicated three times in a random block design. Each experimental plot consisted of at least 60 trees. Meadow mouse population was estimated by live trapping and mark and release method in fall of 1981, spring and fall of 1982 and 1983, and in spring of 1984. Tree damage was recorded as percentage of trees girdled in the spring of 1982, 1983 and 1984. The results indicated that plots with bait stations suffered significantly less tree damage and had fewer meadow mice than plots with one broadcast application of zinc phosphide in fall.

In the fall, 1984, a short term study was conducted to determine the efficacy of waxed bait blocks (0.005% diphacinone and 0.005% chlorophacinone) and broadcast applications (0.005% diphacinone paraffinized pellets, 0.005% chorophacinone paraffinized pellets and 2% waxed zinc phosphide on cracked corn) to control the meadow mouse population. Waxed blocks were placed at 25/ha and the broadcast application was made at 15 kg/ha. This trial was conducted at three locations. Rodenticide treatments were evaluated by determining the mouse activity level before treatment and 30 days after treatment. Also, exhaustive snap trapping was carried out after the 30-day observation to record number of mice per trapping site. The results indicated that both the broadcast treatments (0.005% diphacinone paraffinized pellets, 0.005% chlorophacinone paraffinized pellets and 2% waxed zinc phosphide) and the waxed blocks (0.005% diphacinone and 0.005% chlorophacinone) provided significantly better mouse control as compared to the untreated control treatment; however, the waxed block plots had significantly more mouse activity than the broadcast treatments.

Another part of the 1984 meadow mouse research project was to study the mouse population by dissecting trapped females. This study was conducted at three apple orchards including an abandoned orchard. One hundred snap traps were set at 3-week intervals starting September 20 and ending November 22, 1984. Traps were baited with a piece of fresh apple. Trapped mice were sexed and the females were dissected to record number of fetus' carried by a pregnant mouse. The results indicated that the number of animals trapped declined in late November; however, the number of fetus' and pregnant females increased.

23. SMITH, D.W. and JOTCHAM, J.R. - Environmental properties of triclopyr.

The study of some environmental properties of triclopyr, ((3,5,6-trichloro-2-pyridinyl)oxy)acetic acid), was initiated in 1982.

Soil mobility was examined using intact soil columns and soil thin-layer chromatography. Forest soils were obtained from both northern and southern Ontario, and included sand, clay, organic, and loam soils. Studies with the intact columns indicated that the LFH horizon of northern soils effectively adsorbed triclopyr, but that triclopyr was more mobile in southern soils. Soil TLC studies showed that there was no significant difference in mobility between triclopyr and 2,4-D. Picloram was significantly more mobile than either triclopyr or 2,4-D. Soil adsorption studies with several soils indicated that picloram was adsorbed less than either triclopyr or 2,4-D, and that triclopyr was similar to 2,4-D in adsorption properties.

Plots for triclopyr residues were set out in July 1982. Both soil and vegetation were sampled at intervals throughout the rest of the year. Residues in vegetation were much higher than those in soil. In the vegetation, residues were down to 10% after 2 weeks. Degradation in soil was much slower. Plots for persistence studies were set out in August 1982. A soybean bioassay showed no significant effect 28 days after herbicide application. There was no significant difference between triclopyr and 2,4,5-T. Picloram was more toxic than either triclopyr or 2,4,5-T. A lentil bioassay was more sensitive, with triclopyr having no effect after 56 days.

Plots along an Ontario Hydro ROW were treated with either triclopyr or a formulation of 2,4-D/2,4-DP. Over 100 species were inventoried for density, cover, and quadrat frequency. The results indicated that triclopyr was more efficient for control of white ash and sugar maple than was 2,4-D/2,4-DP. Most grasses were resistant to triclopyr, but smooth brome grass was temporarily damaged, recovering the following year.

Multivariate analyses were applied to the vegetation data. Both Twinspan (a hierarchial polythetic divisive technique) and Decorana (an ordination

technique based on reciprocal averaging) showed that the effect of triclopyr was different from that of 2,4-D/2,4-DP. Both the magnitudes and the directions of floristic change were different, and these differences were still significant two years after treatment.

24. BOWHEY, C., LANGSHAW, J., LIBER, K., SOLOMON, K.R. and STEPHENSON, G.R. - Persistence of 2,4-D in northern and southern Ontario aquatic environments.

Lake #2 in Thackeray Township which, for ease of conversation was renamed as Lake Liber, was chosen as a northern site. The lake, about 5 ha in area, is a typical bog lake in a sandy soil area and a pH of 4.5. The Elora Pond was selected as a southern site and is typical of farm ponds in the agricultural area of Southern Ontario. pH of the water was measured at 8.4. Two sets of six limnocorrals were constructed, bolted together on shore, floated out onto the lake or pond and anchored in place with the aid of concrete block anchors or metal poles driven into the bottom of the pond. The average depth of water at the corral location in Lake Liber was 2.5 m and 1.73 m in the Elora Pond. In order to measure adsorption of pesticide to the walls of the enclosure, six polyethelene strips measuring 1000 x 50 mm and having a total surface area of 1000 cm^2 were hung in the corrals.

The enclosures were treated with 2,4-D isooctyl ester formulation (60% AE) at rates of 1 and 2.5 kg ha^{-1} giving final nominal concentrations of 40 to 144 µg L^{-1} at the Elora Pond on June 19 and Lake Liber on June 26, 1984 between 0800 hours and 1000 hours by means of a surface spray applied by a portable hand-pump sprayer. Water, sediment, algae and plastic strip samples were taken from each treated corral at various intervals. Water temperature and dissolved oxygen readings and visual observations were also taken. All sediment and strip samples were frozen at -17°C. The plastic strips were first wrapped in aluminum foil and placed in individual labelled plastic bags. The water samples were transported to the field laboratory station or to the University of Guelph for immediate processing.

The mean temperature and oxygen concentrations in the corrals showed little difference between the two concentrations of 2,4-D used in the study, either in the northern or the southern study, suggesting little impact on the primary productivity in the system. As expected, temperature showed no difference between any of the corrals and mean temperatures for all corrals are reported. Analysis of residue samples is currently being carried out.

25. BOWHEY, C.S., STEPHENSON, G.R., SEARS, M.K., and LIBER, K. - Dislodgeable pesticide residues on turfgrass in relation to safe entry.

Field experiments were conducted to determine the persistence and dislodgability of amine and ester formulations of 2,4-D applied to turf grass. Dislodgeable residues were estimated by vigorously wiping a 1 m^2 plot with a moistened cheesecloth. There was no rainfall until 11 days after treatment. Immediately after spraying, the ester formulation was significantly less dislodgeable (1.73% vs 6.38%) than the amine formulation. With both formulations there was a very sharp decline in dislodgeable residues to less than 1% of that applied by 4 days after treatment.

Earlier studies indicated a less rapid decline of dislodgeable residues under growth room as compared to field conditions. In additional field studies with the amine formulation, dislodgeable residues as well as residues in various other leaf fractions were monitored under both shaded and unshaded conditions to assess the importance of U.V. degradation. In these studies, conducted out of doors with pots of turf grass, there was again a very significant decline in dislodgeable residues. However, there were no significant differences between the shaded and unshaded treatments.

26. STEPHENSON, G.R., SOLOMON, K.R. , and THOMPSON, D.G. - A review of literature on specific pesticides and related issues to determine future research directions of the Pesticides Advisory Committee.

Two reports, "Dichloraniline-based herbicides: Their contaminants, toxicology and carcinogenic potential" and "Toxicology and carcenogenic potential of 3-amino-1,2,4-triazole: A review of the scientific literature" were prepared and submitted to the Pesticides Advisory Committee.

27. SURGEONER, G.A. and FLANNIGAN, G. - Evaluation of commercial parasites for house fly control in livestock facilities in Ontario.

The commercially available house fly pupal parasites Muscidifurax spp., Spalangia endius and Nasonia vitripennis were released at economically feasible rates in swine, poultry, beef and dairy facilities in Ontario. Parasitism was evaluated by collection of wild pupae and the use of sentinel pupae. Parasitism of house fly pupae in 1983 ranged from 12.9 to 4% and 12.3 to 1.2% in 1984 dependent on the type of livestock facility. There was no evidence of parasite survival through the winter and low level parasitism was believed due to the poor searching capability of parasites (<3 m). Shipments of parasites from commercial suppliers provided number and species of parasites claimed. We conclude that commercial parasites are not a viable control option for house flies in Ontario at the present time.

28. SUTTON, J.C. and BRAUN, P.G. - New approaches to managing botrytis grey mold in strawberries.

The overall goals of this project are to develop practices for managing grey mold which utilize less fungicide or no fungicide and result in little or no fungicide residues in the fruits, and to integrate these practices into a package for use by the grower. As a basis for the new management strategies, we have monitored grey mold epidemics year-round in relation to crop development and environment. Effectiveness of several practices for managing grey mold was assessed in terms of spore production by the pathogen in the normal period of fruit infection (blossoming and fruiting stages) and incidence of diseased berries. The studies were conducted in field plots at Simcoe, Elora and Arkell, as well as in the laboratory.

Observations in the various plot areas indicated that dead strawberry leaves were the principal source of inoculum of B. cinerea in spring. Sporulation on plant crowns and fruit mummies was sparse and infrequent, and sclerotia were not recovered from soil or debris.

At Simcoe, sporulation on samples of dead leaves harvested on 10 May 1984 was much lower in plots which had been machine-harvested in the preceding season than in plots which were hand-harvested (with a picking-aid platform). This was possibly related to the extensive removal of foliage by the machine. The differences in sporulation were no longer evident in samples taken at the flowering stage (5 June). At that stage, spore production (on dead leaves) per unit area of plots was 10 times lower in solid beds than in matted rows of strawberries. Low spore production in the solid beds possibly was related to comparatively sparse canopy development and associated shortening of wet periods and temperature differences. Incidence of grey mold on berries from the matted rows was 24-40% and 10-16% in the solid beds.

At Elora, interactive effects of removing crop debris (by raking) when the crop was renovated in August and seven different fungicides, each applied after rains on 17 September, 27 September and 24 October, were studied with respect to disease intensity in the fall and the following spring. The fungicides did not reduce sporulation on fruit mummies in the fall. Myclozolin, myclozolin plus Bravo®, benomyl plus captan, and Bravo reduced incidence of sporulation by B. cinerea in spring, while mancozeb increased disease compared to the checks. Incidence of B. cinerea on leaves and berries was higher in the plots which were raked to remove debris in the previous August than in non-raked plots.

At Arkell, a data logger and seven weather sensors were used to monitor micro-climate within the strawberry canopy throughout the spring, summer and fall. Relationships of weather and disease progress are being analysed.

In a second study at Arkell, effects of 3 applications of various fungicides timed after rain during the blossoming period were examined. Incidence of

grey mold on the fruits was reduced by all products (applied at recommended rates) but captan was about twice as effective as Rovral®, Dyrene®, Bravo, or Benlate® plus captan.

In the laboratory, effects of 12 fungicides against B. cinerea in colonized dead leaves were examined. Proprionic acid, myclozolin, chlorothalonil and myclozolin plus chlorothalonil prevented sporulation by B. cinerea. Iprodione, benomyl, captan, benomyl plus captan, anilazine and folpet were partially effective. Lime sulfur and mancozeb failed to reduce sporulation incidence.

29. TOLMAN, J.H. and TOMLIN, A.D. - Integrated management of root maggots attacking vegetable crops.

a) Seed treatments for root maggot control.

For the third year, application of the organophosphorus (OP) insecticides, isofenphos, chlorpyrifos and chlorfenvinphos to cooking onion seed at 25 g AI/kg seed proved as effective as furrow application of chlorfenvinphos 5G for control of first generation onion maggot (OM) damage. No detectable residues of any of these insecticides were detected in onions at harvest, 22 weeks after application. Both fonofos, an OP insecticide, and cryomazine, a growth regulator, tested for the first time in 1984, also proved effective against OM. A new soil active pyrethroid did not control OM damage at the tested rates of application (5.0 - 7.5 g AI/kg seed).

Similar microplot results were recorded for both pickling and bunching onions where isofenphos, chlorfenvinphos and chlorpyrifos, applied as seed treatments, were all as effective as furrow application of chlorfenvinphos 5G. Samples of bunching onions harvested 12 weeks after seed treatment showed no detectable residues of any insecticide. Traces of chlorfenvinphos (0.006 ppm) and chlorpyrifos (0.008 ppm) were detected in pickling onions harvested at the same time.

Cabbage maggot (CM) damage in a spring planting of radishes was well controlled by all three OP insecticides applied as seed dressings. Chlorpyrifos and chlorfenvinphos also performed very well in a fall radish planting; isofenphos did not. Neither cryomazine nor the pyrethroid provided reliable control of CM damage to radishes in the fall microplot experiment. Low residues of isofenphos (0.28 ppm), chlorfenvinphos (0.024 ppm) and chlorpyrifos (0.06 ppm) were detected in radishes harvested six weeks after seed treatment.

No seed treatment alone provided effective control of CM attacking summer turnip. Supplementing seed treatment with drench application of

chlorfenvinphos five weeks after seed treatment improved OM control but not to commercially acceptable levels.

All three OP insecticides, applied as seed treatments, provided temporary initial protection of newly emerged summer turnip seedlings against attack by the crucifer flea beetle.

Seed treatments from three other sources were also evaluated during 1984. Drillbox formulations of chlorpyrifos and isofenphos provided by a Canadian agrochemical company did not adhere to cooking onion seed in quantities sufficient to provide effective OM control. A multicomponent seed treatment containing chlorpyrifos and forwarded by the University of Guelph gave good control of OM but was too bulky for use in commercial planters. Pelleted cooking onion seed containing chlorfenvinphos and supplied by the National Vegetable Research Station, Wellesbourne, U.K. proved quite effective against OM and most acceptable commercially. Severe phytoxicity was, however, observed when the rate of application of chlorfenvinphos exceeded 25 g AI/kg seed.

b) Field effectiveness of Aleochara bilineata.

A fairly large 6-block experiment designed to measure field effectiveness of released A. bilineata (AB) for control of OM damage on the Thedford-Grand Bend Marsh was destroyed during a wind storm on June 8. Heavy rain and high temperatures resulted in such a poor onion stand on the replanted experiment that the block was abandoned and a much modified experiment established in a nearby field of commercial onions on June 29. No insecticides were subsequently applied in the experimental blocks.

Four blocks, each nine beds wide x 50 m long and separated from each other by a 10 m buffer were established down one side of the field as follows:

1. Control
2. Weekly AB release of 4 AB/m^2 - 12 releases
3. Monthly AB release of 4 AB/m^2 - 3 releases
4. Single mass AB release of 20 AB/m^2

Parasitism of OM pupae by AB was measured using two techniques:

1. "Beetle bags" (BB) - 3 cm x 6 cm screened pouches filled with muck, containing 10 OM pupae, buried at eight selected locations in the plots for a 10-day period and then removed. Ten sets of BB were processed at weekly intervals during the experiment.

2. "Micromountains" (MM) - 0.25 m^2 tubs of sliced onions seeded with OM eggs, removed from the field 10 days after initial OM pupation. Two MM were processed from each of blocks #1, 2, and 3 on five occasions during the summer.

Higher rates of parasitism were recorded in OM pupae extracted from MM than from BB, probably due to congregation of AB at a readily available food source. Parasitism in BB from block #1 averaged 2.2% over the entire season; pupae from MM in the same block were parasitized at an average rate of 9.3%. Weekly release of AB increased average parasitism in BB to 6.7% but the rate reached 32.5% at the end of the season; parasitism in MM in the weekly release block averaged 19.5% and reached a high of 33.0%. No pupae from BB buried in a block of commercial onions treated with sprays of permethrin (3) and parathion (2) were parasitized by AB.

Due to the improvised nature of the release experiment, no block of insecticide-free onions was available to measure the effectiveness of AB release for control of OM damage to the crop. Examination of 10x100 onions in each block just before harvest showed 1.4% damage due to second generation OM in the control block, 1.1% damage in the weekly release block, 0.5% damage in the monthly release block and 1.3% damage in the field regularly sprayed by the grower.

A technique for marking large numbers of beetles en masse, rather than individually, for release in the field was developed in the laboratory. The release of larger numbers of marked beetles allowed higher recapture rates, which improved estimates of the natural population. Experimental results show that in commercial onion fields exposed to three permethrin plus two parathion sprays, natural AB populations may be very small (75% of AB captures were marked).

Field microplot release of 32 AB/m^2 during the summer proved as effective as furrow application of chlorfenvinphos 5G for the control of OM damage to cooking onions. Both techniques reduced plant loss to ca. 10%; 60% of the onions were lost in control plots. A second experiment carried out during cool fall weather was not as successful. Release of 32 AB/m^2 reduced onion loss from 84% to 45%; furrow application of chlorfenvinphos 5G cut plant loss to 22%. Releases of 8 AB/m^2 and 16 AB/m^2 were not satisfactory.

Significant predation of OM pupae by the ant Solonopsis molesta disrupted an initial attempt to measure parasitism of a known population of pupae in BB in microplots by a known population of released AB. A second experiment in September recorded only limited parasitism of OM pupae suggesting a need for work to determine how AB locate their host in the field. Furrow application of chlorfenvinphos 5G did not affect the limited parasitism observed.

30. TU, C.M., HARRIS, C.R. AND TURNBULL, S.A. - Feasibility of culture and use of Entomophthora muscae as an alternative to insecticides in insect control.

Entomogenous fungi, Entomophthora sp. cause diseases in a wide range of insects, including those in the orders Lepidoptera, Coleoptera, Hemiptera, Orthoptera, and Diptera. In Ontario, E. muscae is one of the most important natural control agents affecting such dipterous insect pests as root maggots and house flies. No completely satisfactory method for its maintenance in vitro or in vivo has been developed and factors governing the invasiveness of infective conidia remain obscure. As a result, evaluation of its potential for use in integrated pest management programs has been restricted.

An artificial medium was developed in the laboratory which preliminary studies indicated would be suitable for culturing E. muscae. Eighty-nine isolates were obtained from diseased onion maggot flies collected at the Keswick Marsh and a pure culture of E. muscae was selected from them for further study. When exposed to the culture growing on the media, onion maggot and housefly adults became sluggish and their abdomens became dilated. The disease progressed very rapidly and within 48-72 hours all of the host's internal structures became liquified and replaced by the fungus. Eventually, the internal hyphal bodies produced conidiophores which penetrated the insect's exoskeleton forming conidia. Studies indicated that moisture and nutrient availability are critical to conidia germination. Conidia would not germinate on a dry surface.

E. muscae is most active in the field under cool, moist conditions, ie. the same environmental conditions under which fungus diseases of crops develop. To determine whether pesticides used in crop protection programs will affect E. muscae growth, 10 fungicides, 20 insecticides, and six herbicides were tested in vitro. All chemicals inhibited fungal growth at the higher concentrations; the herbicides, ioxynil and chlorpropham and the insecticide, chlorfenvinphos had the greatest inhibitory effects.

RESEARCH PROPOSALS FUNDED IN 1983/84 AND REPORTED IN 1984/85

31. CHIDIAC, P. and GOLDBERG, M.T. - Genotoxicity of captan in mouse duodenum.

Preliminary findings in our lab established that the induction of micronuclei and other nuclear aberrations (NA) is indicative of the carcinogenic potential of a given agent in the mouse duodenum. X-irradiation, Benzo(a)-pyrene (B(a)P), N-methylnitrosourea (MNU), and 1,2-Dimethylhydrazine (DMH), all of which are carcinogenic in the small intestine of the mouse, were found to induce NA in male C57Bl/6J and/or CD1 mice in a dose-dependent manner. Benzo(e)pyrene (B(e)P) and methylurea (MU), which are non-carcinogenic analogues of B(a)P and MNU, respectively, did not induce NA under the same conditions.

The purpose of the first portion of this study was to establish that a short-term, organo-specific in vivo assay could be used to detect genotoxic agents. The assay was then utilized to study the mechanism of captan's oncogenesis in the duodenum of the mouse. Orally administered technical grade captan did not significantly induce NA. Depletion of duodenal glutathione with orally administered buthionine sulfoximine, followed 4 hours later by oral administration of technical grade captan, also yielded negative results.

Certain impurities which may be present in commercially available captan have shown to be mutagenic in vitro. Currently, we are investigating the possibility that captan's genotoxicity in the mouse duodenum may be attributable to these impurities.

APPENDIX IV: PUBLICATIONS RELATING TO THE ONTARIO PESTICIDES ADVISORY COMMITTEE RESEARCH PROGRAMS, 1984-85

1. CHAPMAN, R.A., C.R. HARRIS, H.J. SVEC, and J.R. ROBINSON. 1984. Persistence and mobility of granular insecticides in an organic soil following furrow application for onion maggot control. J. Environ. Sci. Hlth. B19: 259-270.

2. GEORGE, J.A. 1983. Survival of the mosquito predator Dugesia tigrina (Tricladida: Turbellaria), over three years in catch basins. Proc. Ent. Soc. Ont. 114: 83-85. (Published 1984).

3. MILES, J.R.W., C.R. HARRIS, and C.M. TU. 1984. Influence of moisture on the persistence of chlorpyrifos and chlorfenvinphos in sterile and natural mineral and organic soils. J. Environ. Sci. Hlth. B19: 237-243.

4. PIEDRAHITA, O. and C.R. ELLIS. 1985. Effect of spacing and clumping of corn plants on density of corn rootworm larvae (Coleoptera: Chrysomelidae) per root system. Can. Ent. 117: 139-142.

5. PIEDRAHITA, O., C.R. ELLIS, and J.P. BOGART. 1985. Interactions of northern and western corn rootworm larvae (Coleoptera: Chrysomelidae) in a controlled environment. Environ. Entomol. 14: 138-141.

6. PIEDRAHITA, O., C.R. ELLIS, and J.P. BOGART. 1985. Electrophoretic identification of the larvae of Diabrotica barberi and D. virgifera virgifera (Coleoptera: Chrysomelidae). Ann. Ent. Soc. Am. (In Press).

7. SUTTON, J.C., P.M. ROWELL, and T.D.W. JAMES. 1984. Effects of leaf wax, wetness duration and temperature on infection of onion leaves by Botrytis squamosa. Phytoprotection 65: 65-68.

8. TOMLIN, A.D., J.J. MILLER, C.R. HARRIS, and J.H. TOLMAN. 1985. Arthropod parasitoids and predators of the onion maggot (Diptera: Anthomyiidae) in southwestern Ontario. J. Econ. Entomol. 78. (In Press).

9. THOMPSON, D.G., G.R. STEPHENSON, K.R. SOLOMON, and A.V. SKEPASTS. 1984. Persistence of (2,4-Dichlorophenoxy) acetic acid and 2-(2,4-Dichlorophenoxy) propionic acid in agricultural and forest soils of northern and southern Ontario. J. Agric. Food Chem. 32: 578-581.

10. WHISTLECRAFT, J.W., C.R. HARRIS, J.H. TOLMAN, and A.D. TOMLIN. 1985. Mass rearing technique for Aleochara bilineata (Coleoptera: Staphylinidae) J. Econ. Entomol. 78. (In Press).